COMPREHENSIVE BASIN MANAGEMENT PLAN

FOR THE ILLINOIS RIVER BASIN

IN OKLAHOMA

Prepared by

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EXHIBIT
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EXECUTIVE SUMMARY

The Illinois River Watershed (including Lake Tenkiller) in northeastern Oklahoma is one of the State's most valuable and controversial watersheds. Considerable effort has focused on studying the watershed to identify problems, causes, and potential solutions. These studies have concentrated primarily on water quality (both in the river and lake), land use, and the relationship between the two.

This report attempts to summarize the main historical research on water resources in the basin and then summarize what various government agencies have done or plan to do to remediate problems in the watershed. Many steps have already been taken to reduce pollution in the watershed; however, significant sources must still be addressed to protect the river and Lake Tenkiller.

The watershed extends from Northwestern Arkansas (Benton, Washington, and Crawford Counties) to Northeastern Oklahoma (Delaware, Adair, Cherokee, and Sequoyah Counties)(**Figure A**). Arkansas has developed their own plan to address water quality problems in the river and this report will outline a similar plan for Oklahoma. As such, this report will only address the Illinois River Watershed (including Lake Tenkiller) in Oklahoma.

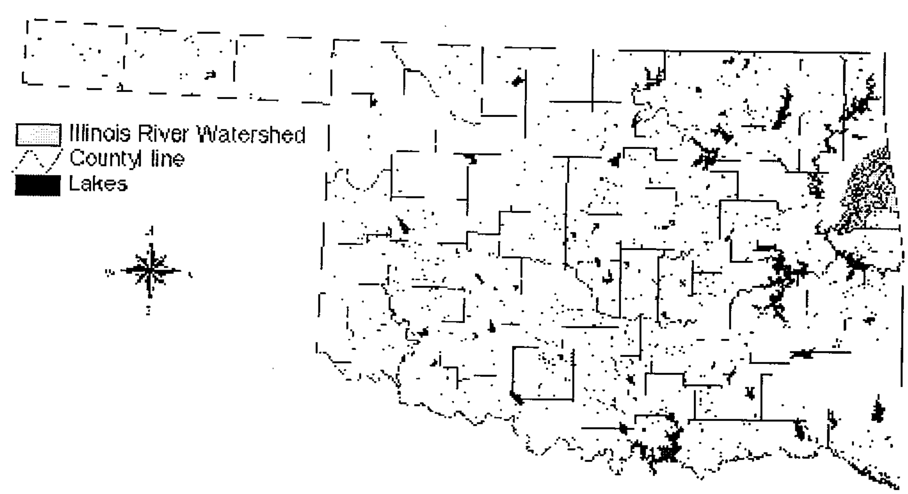

Figure A. Location of the Illinois River Watershed in Oklahoma.

Much of the initial investigation into the water quality of the basin was due to the perception by local citizens that water clarity had declined in the river, its tributaries, and in Lake Tenkiller (**Figure B**). Research was necessary to determine whether this perception was

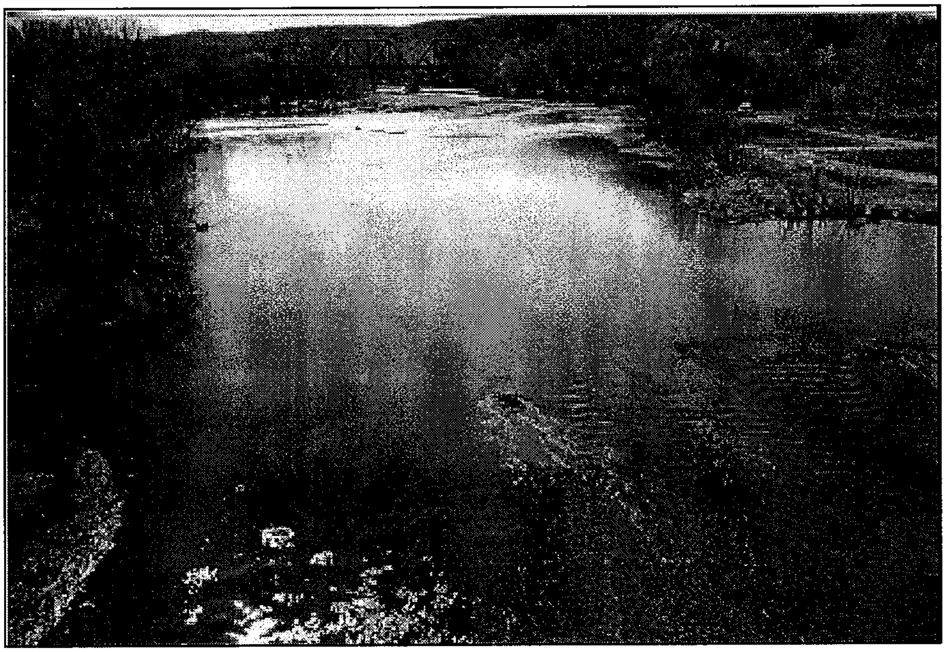

Figure B. Declining Water Clarity in the Illinois River Prompted Research and Protection Efforts.

valid or merely a manifestation of negative opinions concerning the blossoming poultry industry in the basin. Results indicated that there was cause for alarm; nutrient concentrations were high in the river and Lake Tenkiller and nutrient concentrations appeared to be increasing while clarity was decreasing. Data also revealed low dissolved oxygen and frequent algae blooms in the lake which indicated advancing eutrophication. Other studies revealed streambank erosion as a potential significant source of nutrients and sediment to the system. Overall, data indicated a decline in water quality which could translate into future loss of the river and Lake Tenkiller as a water supply, recreation, flood control, and biological resource.

Land use analysis correlated this decline in water quality to dramatic changes in land use in the basin. Agriculture increased substantially in the basin in the form of confined animal feeding operations (CAFOs), primarily poultry operations, and forest land continues to be cleared for pasture and hay production. Overall, these land use changes resulted in a net increase in the amount of nutrients entering the watershed (primarily through animal feed) without a concomitant increase in the amount being exported from the watershed. The resulting imbalance in the nutrient import/export cycle is manifested in the water quality of the basin.

However, agriculture cannot be cited as the sole source of water quality problems in the watershed. Other sources include point sources (pollution discharged by a large, stationary, identifiable sources such as wastewater treatment plants or factories) of pollution which currently include only municipal discharges, but in the past have included industrial discharges, and various nonpoint (pollution from multiple, diffuse, poorly identifiable sources such as agricultural or urban runoff), and combined sources (pollution from both point and nonpoint sources) of pollution. Additional nonpoint sources include recreation, the remains of Lake Frances, urban runoff, gravel mining, and streambank erosion. Combined sources (sources with essentially both point and nonpoint source pollution) include nurseries and urban runoff.

POLLUTION SOURCES

Point Sources

Although point source discharges in Oklahoma did not account for the majority of the nutrient loading to the river and Lake Tenkiller, the load was significant enough to warrant reduction. Significant upgrades have already been implemented on point sources in Oklahoma due to efforts of the Oklahoma Department of Environmental Quality, Cities of Tahlequah and Stillwell, U.S. Environmental Protection Agency (EPA), and the unfortunate closing of the Stillwell Cannery. Combination and elimination of discharges has resulted or soon will result in 2 of the 3 remaining discharges undergoing tertiary treatment. These discharges have phosphorus limits (< 1 mg P/l) written into their permits. The result of these upgrades is a significant decrease in the point source load to the river. However, diligence towards reducing loads to the river must be maintained during operation of the plant to reduce likelihood of accidental spills and storm-related overflows of lagoons (**Figure C**).

Figure C. Sewage Foam Below a Discharger Following an Accidental Discharge.

Nonpoint Sources

Recreation

The recreation industry has been a potentially significant source of pollution in the form of human waste and trash. Although the actual impact to water quality from the recreation industry is difficult to measure, it is not difficult to imagine the effects of over 400,000 river users and 1,500,000 lake users annually given the lack of restroom facilities and the visible trash left behind (**Figure D**). The recreation impact is likely more severe on the river than the lake due to the fact that an average 2,400 people per weekend float the river during peak months and until 1994 only one or two inadequately maintained toilet facilities were available.

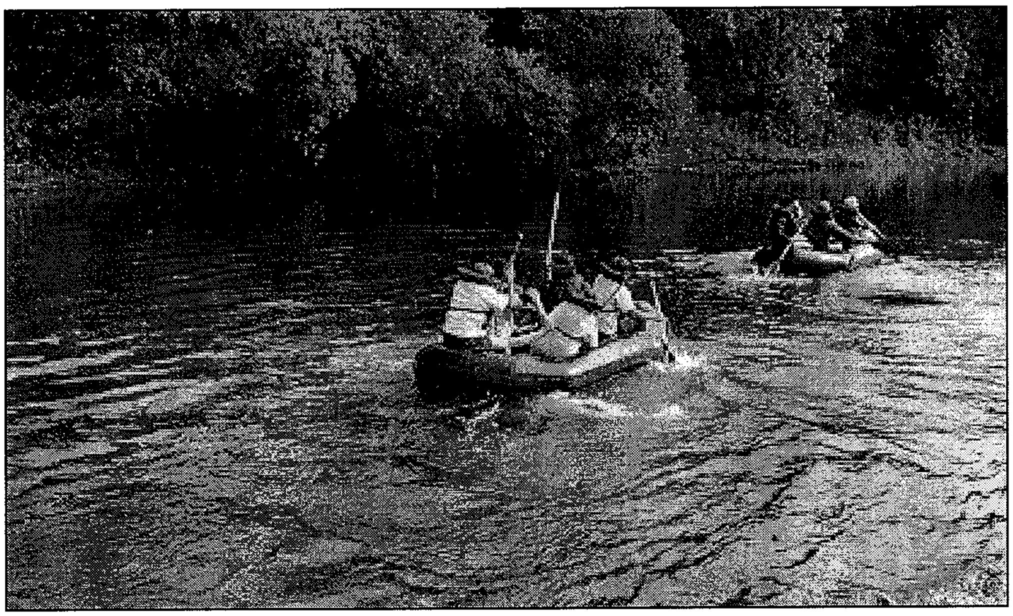

Figure D. The Illinois River Supports a Substantial Recreation Industry.

Recent projects conducted primarily by the Oklahoma Scenic Rivers Commission in cooperation with the Oklahoma Conservation Commission (OCC), Cherokee County Conservation District, and US EPA have resulted a dramatic increase in the quality and quantity of facilities available to river users. These improvements include canoer-only access areas complete with toilet, picnicing, and camping facilities, properly maintained pit and portable toilet facilities dispersed along the river route (cleaned out twice daily during peak season), and the provision of trashbags and trash collection points along the river route. This change has resulted in the removal of over 3,000 gallons of raw sewage from the canoer access area alone that would likely have otherwise reached the river. In addition, an estimated 110 - 120 tons of litter which may have otherwise remained in the river are removed annually due to the trashbag program.

Lake Frances

The collapse of the Lake Frances Dam in 1991 resulted in an additional source of nonpoint source pollution to the Illinois River basin in Oklahoma. The collapse exposed several hundred thousand cubic meters of nutrient-enriched lake bed to potential erosion. The primary concern is loss of sediment during storm events (**Figure E**). Although several options have been discussed concerning the former lake, including reconstruction of the dam and dredging the sediments, the streambed appears to be stabilizing itself and the best option may be to leave the system alone. The former lake bed now exhibits many of the characteristics of a wetland and if left alone to develop, may serve as a valuable nutrient sink and sediment filter to reduce downstream loadings the river and Lake Tenkiller.

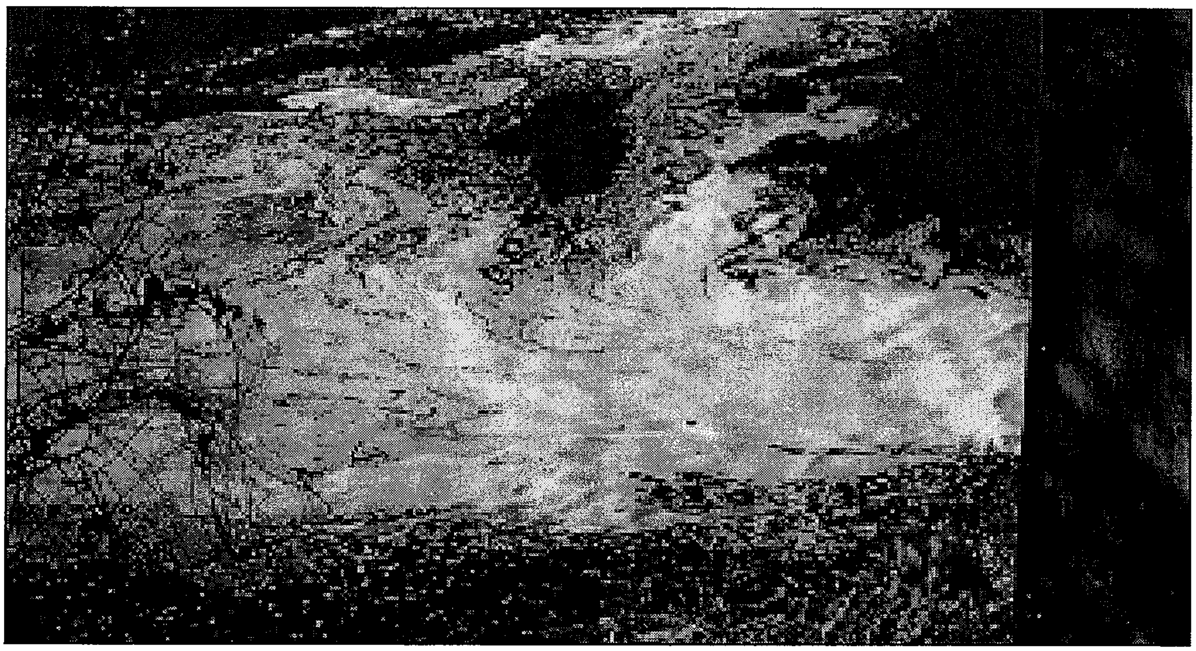

Figure E. Sediment-Laden Water Below Former Lake Frances After a Storm Event.

Animal Production Operations

Animal Production Operations provide the majority of agricultural income in the watershed and indeed are the largest industry in the basin (**Figure F**). Unfortunately, the influx of feed necessary to grow animals in such operations has resulted in an imbalance of the nutrient transport in the watershed. More nutrients enter the watershed in feed than leave the watershed in animal products. The result is that these left over nutrients, in the form of animal waste, are left in the watershed and ultimately make their way to the river and lake.

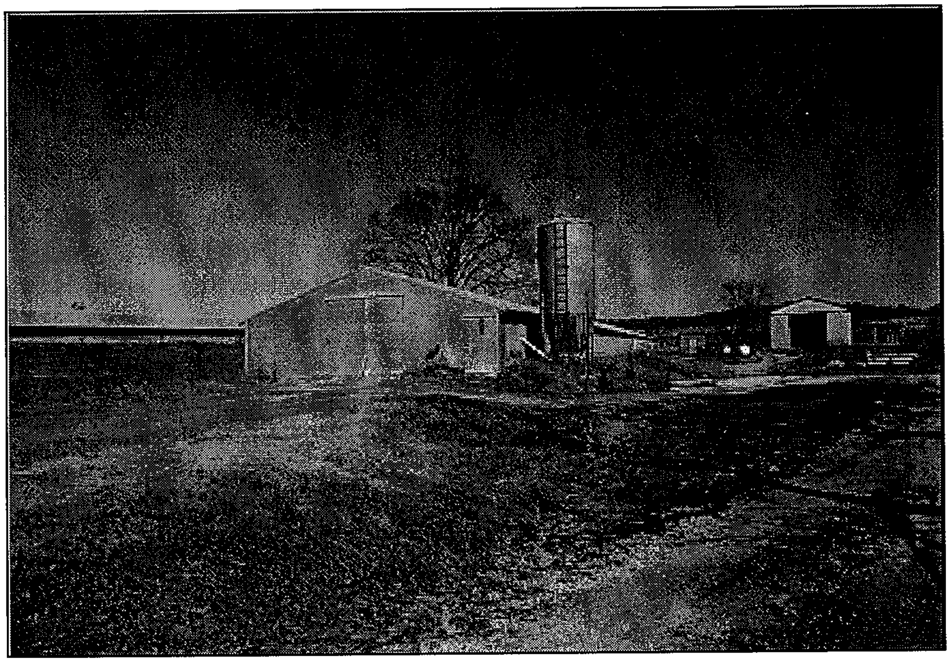

Figure F. Poultry Houses in Eastern Oklahoma.

A 1997 survey of confined animal operations in the watershed identified sites in the watershed, noted the number of houses present, and whether or not they were in production. Based on this survey and literature-supported estimates of nutrient production for various livestock, an estimated 13,256,000 lbs. of nitrogen and 4,284,800 lbs. of phosphorus are excreted annually by confined animals in the watershed. The survey also suggested that chickens produce 36% and 34%, turkeys produce 9% and 10%, dairy cattle produce 2% and 5%, hogs produce 9% and 10%, and beef cattle produce 44% and 41%, respectively of the nitrogen and phosphorus excreted in the watershed. These numbers suggest that although the poultry industry secrete a significant amount of nutrients, an even larger portion is secreted by beef cattle. This is important because beef cattle management is such that cattle often have direct access to streams. Thus, cattle may act as a point source and deposit the nutrients directly into the stream, while poultry waste accesses the stream mainly through overland flow. In addition, pasture management is not always optimal. Grazing land is scarce and pastures are often over grazed, resulting in poorer pasture with a lower capacity to process animal waste and prevent it from reaching the stream (**Figure G**).

Various solutions are available to reduce the impacts of this industry on water quality, ranging from reduction in animal numbers, installation of best management practices, and transport of wastes out of the basin. The installation of best management practices to reduce the transport of waste to the waterways is probably the best short-term approach. Mechanisms are in place to focus on this issue. The OCC will be devoting over 2 million

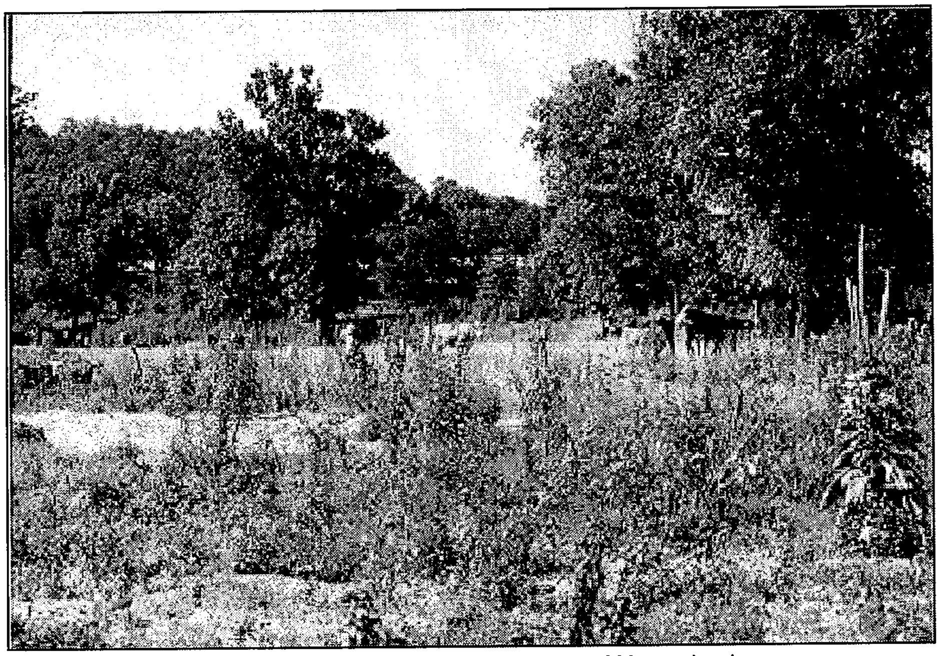

Figure G. Cattle Grazing in The Illinois River Watershed.

dollars between 1999 and 2004 to implement best management practices to reduce nutrient and sediment loading to the river. Many of these practices will help producers reduce the amount of waste reducing the river. This program is a cost-share program with required monetary or labor buy-in from the producer. The program will focus on areas where the concentration of pollution sources is the greatest. The assessment of need is based on water quality data, land use surveys, and locally-driven decision-making. A locally-led watershed advisory group (WAG) will be established to determine what kinds of practices will be available for cost-share funding and how the program should be administrated at a local level.

Waste transport out of the basin is being investigated as a future long-term solution. Transport costs are an issue as well as making sure that the waste is not being transported to an area where it will cause water quality problems.

On-Site Waste Disposal

The majority of the human population in the watershed relies on septic systems to dispose of residential wastes. 1990 census estimates suggest over 27,000 septic systems are in place in the 3 main Oklahoma counties of the watershed. Previous work in small subwatersheds in the basin (Battle Branch) suggested only about 25% of the on-site waste disposal systems met state requirements. These inadequacies range from insufficient lateral lines, lack or insufficient septic tanks, direct disposal of grey water to streams, ditches or land surfaces, and improperly located tanks and lateral lines. Extrapolation to the whole watershed suggests the potential for 75% of rural households to have sub-standard systems. Although many well-maintained residences exist in the watershed, residences like those shown in **Figure H** are not uncommon.

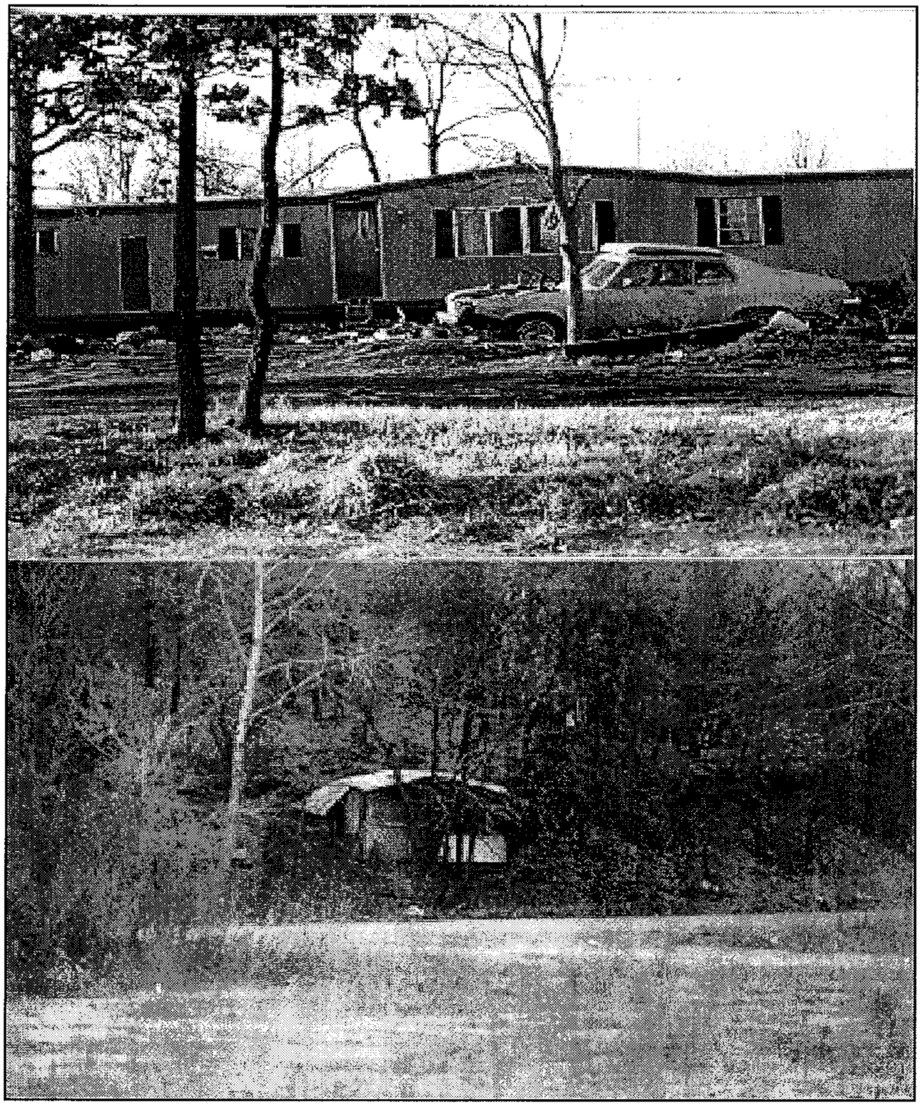

Figure H. Types of Residences in the Illinois River Watershed Which Typically Lack Adequate Septic Systems.

Solutions to the problems include connections to waste water treatment facilities or upgrading/installation of proper on-site waste disposal systems. The most cost-effective alternative is installation of or upgrading to proper on-site systems. This will require on-site investigation of current septic systems which will require additional personnel to those already in place with the Oklahoma Department of Environmental Quality (ODEQ) for that purpose. Cost of installation in the average residence varies between $1500 and $2500.

Probably the most feasible means to facilitate these installations is as part of an overall cost-share program to protect water quality administered through conservation districts.

Gravel Mining

In-stream and near-stream gravel mining threatens water quality and the overall aquatic community through exposure of bed load and stream banks to erosion. Recent investigation into the impact of gravel mining on the Baron Fork River revealed that mining activities had significantly impacted the riparian community and changed the morphology of the channel to an unstable configuration (Rosgen D classification) which is unlikely to restabilize itself without major structural modifications (OCC 1999). The resulting changes in stream morphology led to a wider, shallower, less stable stream (**Figure I**).

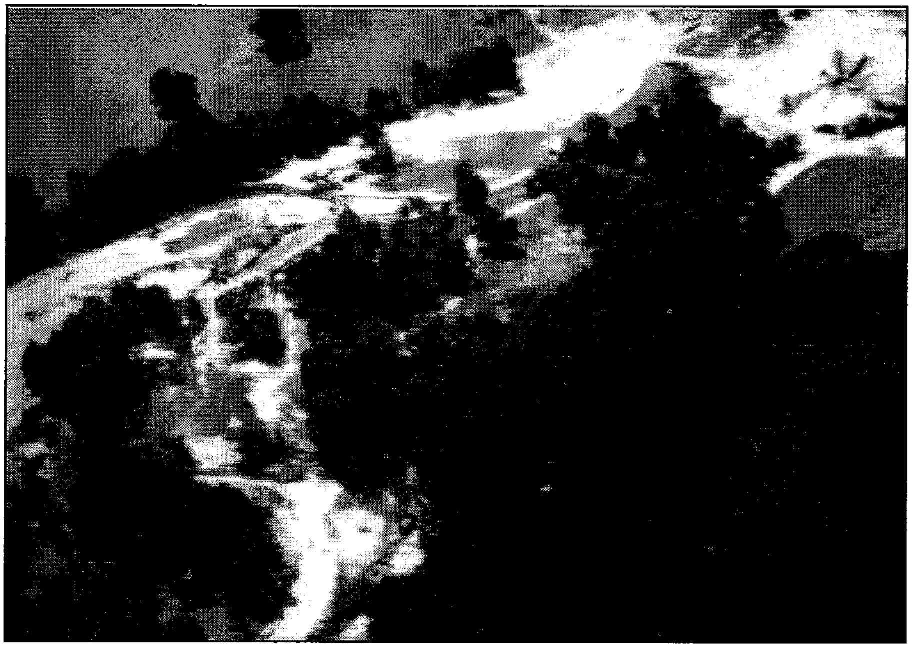

Figure I. Effects of Gravel Mining on The Baron Fork River.

Solutions to the problem range from restricting mining activities to training mine operators to regulating effluent water quality from mining operations. Training and regulations would require additional staff for Oklahoma Department of Mines and perhaps for Extension Service or Conservation Districts. The most feasible alternatives will probably involve more stringent limitations on the locations and extent of mining activities as well as training for mine operators to limit the impacts of their operations. Some site restoration operations may be necessary to repair damages already incurred.

Bank Erosion

Bank erosion along the Illinois River and its tributaries poses a substantial threat to the system. Eroding banks provide sediment, gravel, and nutrients which destroy valuable land, degrade water quality, destroy critical aquatic habitat, and eventually fill in Lake Tenkiller (**Figure J**). This bank erosion is often caused by elimination or poor maintenance of the riparian zone, bridge construction, upstream or downstream changes in channel morphology and/or various upstream land use changes. Estimates of the loading from bank material suggest that eroding banks contribute a significant amount of the total nutrient load in streams (OCC 1999).

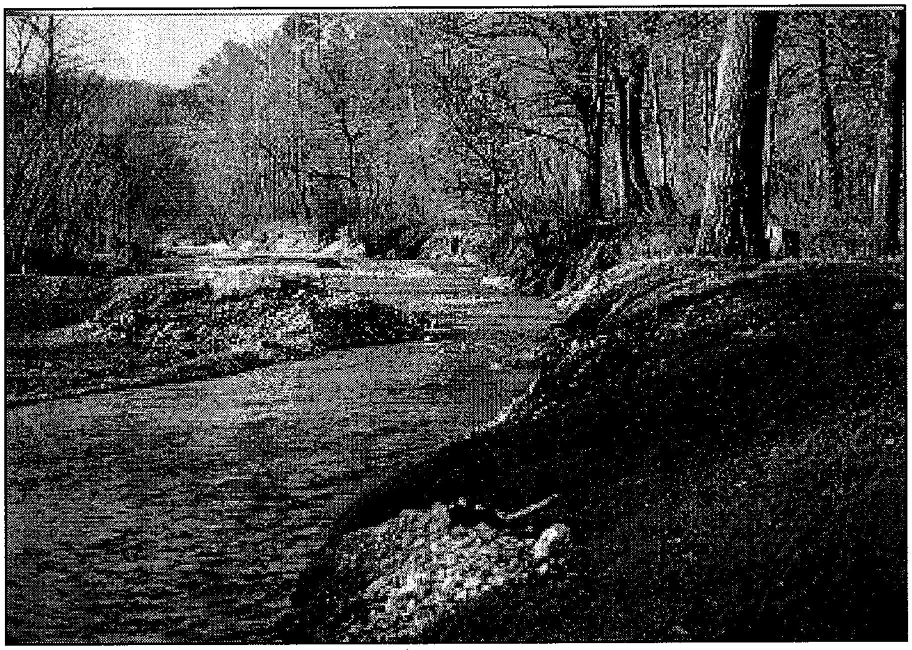

Figure J. Bank Erosion in the Illinois River Watershed and Resulting Gravel Bars.

The most appropriate solution to this problem is to establish and protect riparian areas. This may or may not require fencing and restricted and/or limited use of near-stream areas, but protection of these areas will allow native vegetation to establish which is often the only protective measure necessary. Roots of native vegetation hold soil in place and protect against and dissipate the force of high flow events.

However, in some extreme cases, active restabilization work is necessary to protect the bank. The OCC has successfully completed several of these projects across the state, one of which is located on the Illinois River at Echota Bend. For less that half of the cost of conventional methods, bank stabilization measures were constructed using natural materials that restructured the channel as closely as possible to its natural configuration, creating a system that was more equipped to withstand erosive pressure of high flows, but also protected landowners assets and provided better fish habitat.

Other Sources

A number of other nonpoint sources exist in the watershed which are not detailed in this report or plan. The reason for this omission is either due to insufficient ability to make estimates of the significance of these sources or known lack of significance considering the other nonpoint sources identified in this document. These other sources include but are not limited to wildlife, natural background loading due to geology and natural vegetation of the basin, illegal dumping (**Figure K**), and smaller livestock facilities such as people who keep a few head or horses or cattle.

Figure K. Illegal Dumpsites are an Additional Source of Nonpoint Source Pollution.

Although all of these other sources currently seem to be insignificant, reduction in the impacts from other sources may magnify the effects of these sources. Thus, it may be necessary to revisit and better define the magnitude of these sources once steps have been taken to reduce the impacts of known significant sources. In addition, education programs like those run by the OSRC and Cherokee County Conservation District are critical to reducing all types of nonpoint source pollution. Their goal is to provide citizens with an understanding of how pollutants reach the water, what types of effects they can have, and things people can do to reduce the impacts of pollution. Those education programs may be a significant tool towards reducing other minor sources.

Combined Sources

Urban Runoff

Urban runoff combines the effect of both point sources and nonpoint sources in that at times it contains pollution from point sources (in the form of overflows and system breaks) and overland flow. The urban areas in the Oklahoma portion of the watershed are small and thus likely produce only a small portion of the total pollutant load to the watershed (not counting discharged treated wastewater).

The most appropriate solution to the urban runoff solution is an education program targeted at providing urban dwellers with practices that reduce urban nonpoint source pollution. Coupled with this education program, stormwater permitting programs might be necessary to ensure the city planners and other appropriate entities incorporated nonpoint source pollution reduction into long-term goals.

The Cherokee County Conservation District and the Scenic Rivers Commission currently have education programs in place which provide citizens of the area with the knowledge to reduce Urban Nonpoint Source Pollution from their activities. The cities in the watershed are under the minimum size where stormwater permits are required. Should further research indicate urban stormwater runoff has a significant impact on the river, stormwater permits may be necessary in the future.

Nurseries

Two major nurseries are located along the Illinois River and one is located on the shores of Lake Tenkiller (**Figure L**). Irrigation tailwaters from the two largest nurseries have been shown to contribute significant quantities of nutrients to the basin. Oklahoma State Department of Agriculture estimates that one of the nurseries on the river contributed as much as 0.3% of the nitrate load and 0.19% of the yearly total phosphorus load to the river. The nursery on the shore of Lake Tenkiller was shown to contribute 1.95% of the total nitrate and 1.13% of the total phosphorus load to the lake. This loading was based on irrigation return flows and thus storm runoff from the nurseries was not even monitored. Stormwater runoff could have an even more significant impact.

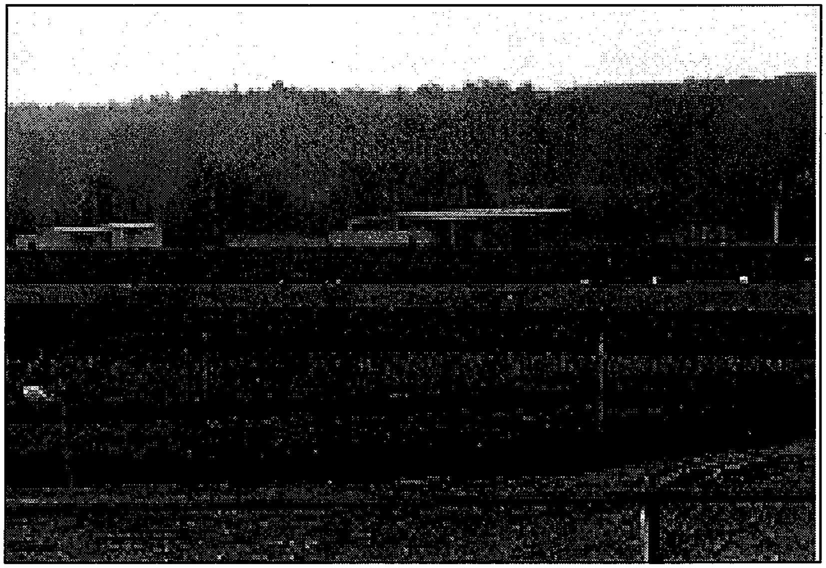

Figure L. Nursery in the Illinois River Watershed.

The most workable solution to limit pollution from nurseries is to capture, treat, and recirculate irrigation and stormwater runoff from the site rather than allowing it to flow into the river or lake. This is being implemented at the lakeshore nursery. Tailwaters are captured and recirculated through the irrigation system to create a total retention system. A pond was constructed for irrigation and much of the stormwater runoff to filter into. This pond serves as a holding and treatment basin for the tailwater. Testing of the water has revealed that it does not contain toxic levels of fertilizer or other plant hazards such as fungus. This total retention system will result in a significant decrease in the nutrient load from nurseries to the watershed.

EFFECTIVENESS OF NONPOINT SOURCE NUTRIENT CONTROL PROGRAMS

Control of nonpoint source pollution on a complete watershed basis has been completed on only one watershed in the Illinois River basin. Oklahoma's first 319(h) demonstration project was implemented between 1990-1993 in the Battle Branch watershed. Approximately $100,000 worth of technical assistance, landowner contact, and BMP implementation over a 5970 acre watershed focused on practices aimed at reducing nutrient loading to Battle Branch Creek. This project "demonstrated" that BMPs could reduce nonpoint source pollution, but even more importantly, that the success of a nonpoint source pollution reduction program is based largely on the level of voluntary participation from the landowners. Approximately 84% of the landowners in the watershed participated in the project which was a significant factor behind its success.

Practices implemented included development and implementation of conservation plans, waste management plans, installation of septic tanks, dairy lagoons, poultry composters, waste storage structures, and improved management of pastures, forest land, hayland including soil testing and tree planing. Implementation of these practices resulted in significant reductions in the nitrogen and phosphorus concentrations at baseflow and during runoff events in Battle Branch Creek at a cost of approximately $16.75 per acre.

FUTURE PROGRAMS

One of the most critical future developments to protect the water resources of the basin will be the total maximum daily load (TMDL) currently being generated by the ODEQ. The TMDL will help appropriate an acceptable load between point and nonpoint sources. This acceptable load is one that will protect both the Illinois River and Lake Tenkiller for future use.

A critical part of the implementation of this TMDL is already underway in the form of a nonpoint source reduction program. Although the TMDL may require further point source reductions, the majority of load reduction necessary in Oklahoma will be through nonpoint source reductions.

The Oklahoma Conservation Commission has allocated significant funds toward a program to implement nonpoint source reductions in a cost-share program. Between 1999 and 2004, over 2 million dollars will go towards reducing nonpoint source pollution from various landuses in the basin. Many of these practices will focus on reducing the impact of animal waste on the basin; however, practices will also reduce streambank erosion, the impact of human waste, and the impact of various other human activities which affect water quality. Another critical component of the plan is the education component which will focus on educating the citizens and users of the watershed on the importance of water quality and practices which can be implemented to protect the aquatic resource.

This multi-million dollar effort will be directed through the activities of a watershed advisory group, made up of local decision makers and other concerned parties. They will offer assistance to land-owners on a cost-share basis to implement practices to protect water quality. The program will also monitor the affects of the program on the aquatic resources of the basin, in order to verify whether BMP installation improves water quality in the basin.

In conjunction with this program, several other programs are underway in the basin to reduce nutrient loading to the system. The Natural Resources Conservation Service will also focus funds towards cost-share assistance to reduce nonpoint source loading in the basin. The ODEQ continues to work with municipal dischargers and private citizens to reduce the impact of point sources and septic tanks to the system. The poultry industry is currently required by Oklahoma law to apply chicken litter on a soil phosphorus content ratio, rather than based on nitrogen needs or litter in need of disposal. This limitation should help focus phosphorus from chicken litter to areas of the watershed with lower soil phosphorus and prevent the continued phosphorus saturation of soils in the basin. Education efforts by the Scenic Rivers Commission, local Conservation Districts, and other state education programs continue to focus on protecting the basin's natural resources.

In addition to the efforts previously described, the Scenic Rivers Commission has adopted a management plan to focus on protecting water quality within their area of jurisdiction (Illinois River between the Arkansas/Oklahoma State line and the headwaters of Lake Tenkiller). This plan includes specific goals toward reducing the nutrient load to the river and Lake from all potential sources. The plan also focuses on overall improvement of the resource, both from the standpoint of safety and resource quality.

COST OF REMEDIATION

The overall cost of remediating the problems in the Oklahoma portion of the Illinois River Watershed will be quite high and may be unrealistic, given the economic resources available. Thus, remediation efforts must focus in the most cost-effective manner. Thus, most of the future efforts should probably focus on reducing the impact to the watershed from animal production operations. Much is already being done to reduce nutrient impacts to the watershed and substantial funds have already been allocated towards reducing point source and nonpoint source loading. Additional funds necessary to protect the water resources may be difficult to estimate prior to the completion of the TMDL and before the success of currently planned programs to reduce nonpoint source pollution can be assessed.

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INTRODUCTION

ILLINOIS RIVER COMPREHENSIVE BASIN MANAGEMENT PLAN

The purpose of this document is to develop a comprehensive management plan for the Illinois River Basin in Oklahoma to devise a systematic approach to addressing pollution problems in the basin. Historically, most discussion of river problems have focused on single areas and it is hoped that this document will push the state towards a holistic view of problems within the basin. The State of Arkansas has developed a similar document for the portion of the basin within their state which will be combined with Oklahoma's plan to create a complete basin management plan. This report will attempt to incorporate efforts of other state agencies in the Illinois River basin. The Oklahoma Scenic Rivers Commission has developed a management plan for the river corridor (OSRC 1998). Although the OSRC plan pertains only to the river corridor (generally the land within 1/4 mile on either side of the river, includes the Illinois River from the Oklahoma state line downstream to the confluence with the Baron Fork, and its two major tributaries, Flint Creek and Baron Fork Creek), many of the ideas are applicable basin wide and this report will correlate with the OSRC plan. This report could be considered as part of the overall statewide nonpoint source management plan and as such could serve as a template for future work in other priority watersheds (The statewide nonpoint source management plan is subject to public review. Therefore, should the review process indicate that this document is not appropriate for inclusion in the statewide plan, it will not be included). This document should also provide foundation for the implementation of the nonpoint source portion of the Total Maximum Daily Load (TMDL) for the basin established by the Oklahoma Department of Environmental Quality (ODEQ).

This document is organized into several sections, each of which deals with a different river issue. The first section introduces the Illinois River, characterizing its location and statistics. The second section summarizes studies previously conducted within the river basin. This section is intended to familiarize those who are not aware of river problems with basic water quality issues. The third section covers the major sources of pollution along with an estimation of their contribution to river problems. This section also discusses potential solutions and costs.

The fourth section outlines the process of best management practice (BMP) implementation in small watersheds by detailing the results of the first implementation project in the basin. In the fifth section, future programs, both needed and planned are discussed. The final section summarizes the estimated costs for the different approaches to water pollution control.

This document should present an understanding of the complex problems within the basin and estimates of the costs of remediating those problems. Although it is relatively simple to estimate the costs of clean-up programs in terms of construction or implementation, it is very difficult to estimate other impacts. The reader is encouraged to consider the socio-economic impacts of such practices as reducing animal numbers or mandating waste control practices on the citizens of the river basin.

For each of the pollution sources discussed, potential solutions are provided. It should be stressed that 'no action' is a viable alternative in all cases. The effect of this approach should be considered for all sources and weighed against the costs. It is unlikely that all sources of pollution within the basin can be eliminated; therefore, difficult decisions are necessary. Both long-term and short-term consequences should be analyzed for each area and weighed against others.

OKLAHOMA'S GOAL FOR THE ILLINOIS RIVER

The Illinois River and its tributaries are viewed as outstanding water resources for the purpose of their recreation, wildlife propagation, and aesthetic values. It is further recognized that the Illinois River and its tributaries are the primary sources of water for Tenkiller Ferry Reservoir, another outstanding water resource, and as such are directly responsible for reservoir water quality.

Oklahoma's goal is to maintain the quality of these water resources at the highest practical level by improving those practices which may contribute to water quality degradation. This will be accomplished through the identification and prioritization of problem areas followed by implementation of practices or procedures which will lessen the impact of individual sources to a practical minimum.

It is understood that the Illinois River and Tenkiller Ferry Reservoir have already experienced significant water quality deterioration as a result of both point and nonpoint sources of pollution and that specific contributors from both source categories must be addressed to prevent further degradation. Finally, it is recognized that significant improvements in river water quality must be accomplished if the river and reservoir are to remain classified as outstanding resource waters.

AREA DESCRIPTION

The Illinois River watershed straddles the Oklahoma/Arkansas border and of its 1,069,530 total acres, 576,030 (approximately 54% of the total basin area) are located in Oklahoma (USDA 1992). In Oklahoma, the watershed can be further sub-divided into 60 smaller watersheds ranging in size from 2382 to 31,046 acres with a mean size of 8825 (**Figure 1** & **Figure 2**). The basin is located in Delaware, Adair, Cherokee, and Sequoyah counties in northeastern Oklahoma.

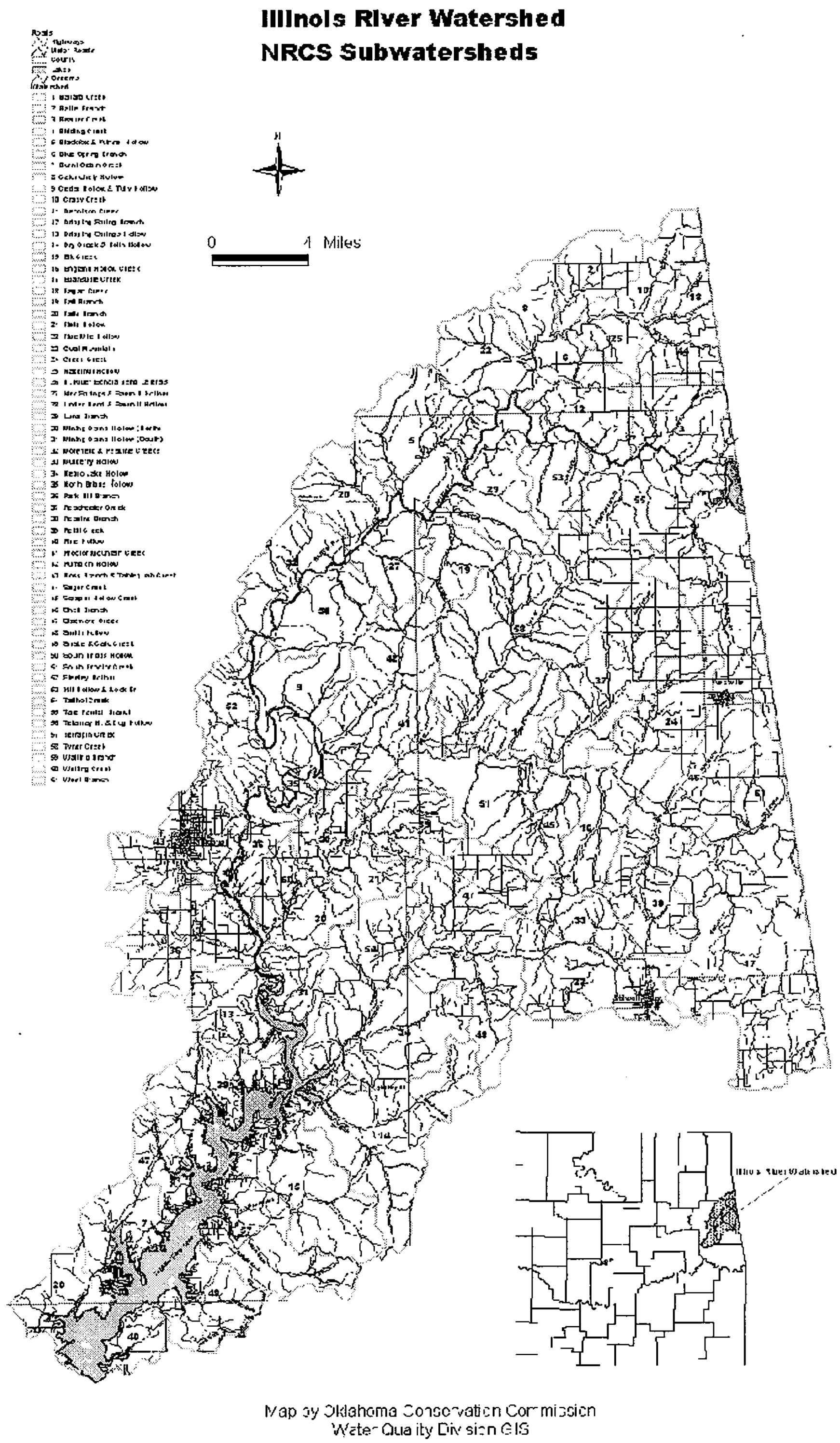

Figure 1. Map of Illinois River and major tributaries indicating approximate locations of subwatersheds.

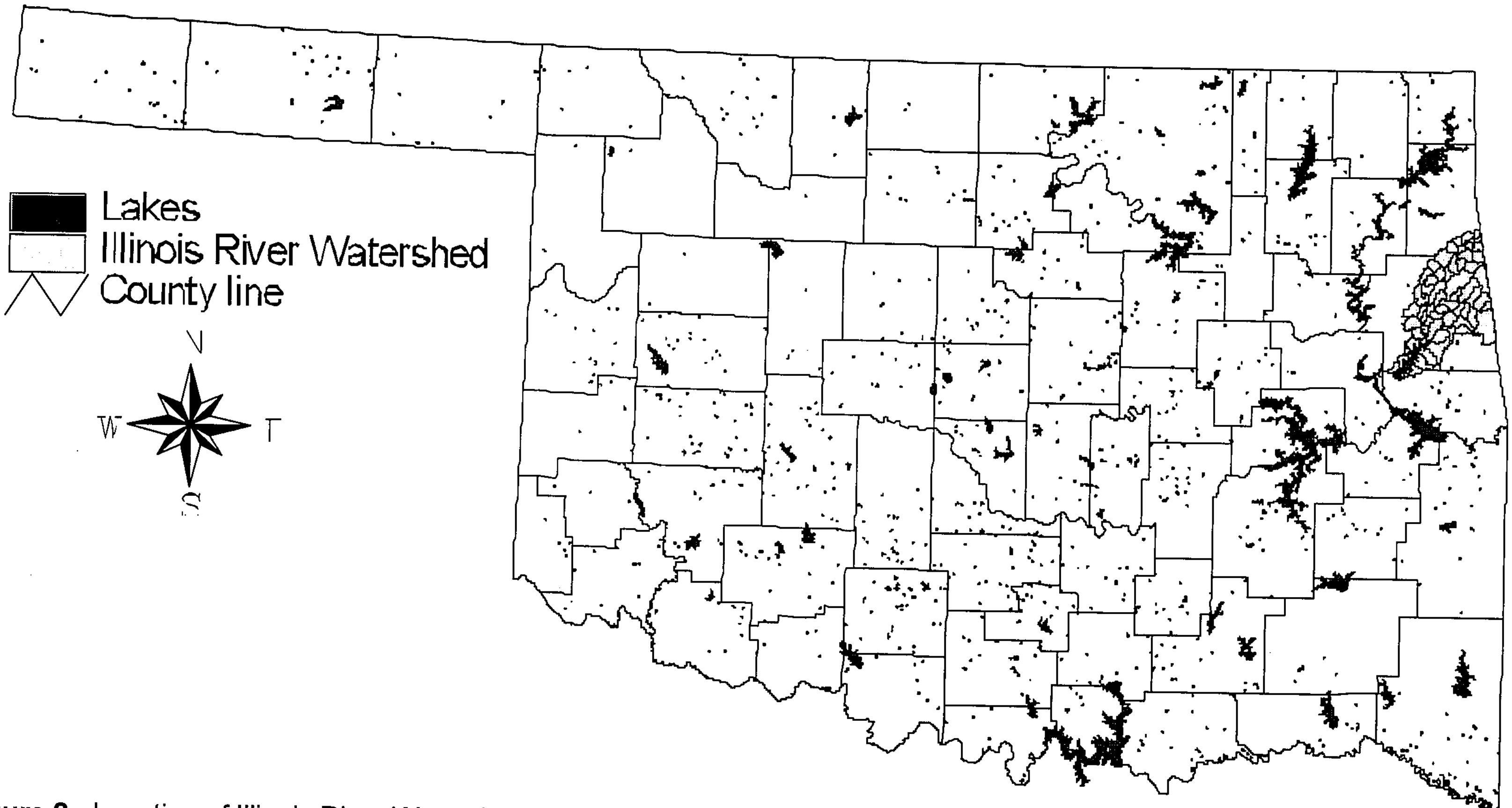

Figure 2. Location of Illinois River Watershed in Oklahoma.

The average flow of water in the river as it enters Oklahoma near Watts is 703 cfs which increases to 1095 cfs as the river reaches Tahlequah (USGS database, period of record 10/81 - 09/91), shortly after which it flows into Lake Tenkiller. The major tributaries of the Illinois River in Oklahoma are the Baron Fork River, Caney Creek, and Flint Creek.

The river is classified as a state scenic river from the Lake Frances Dam down to its confluence with the Baron Fork, a distance of approximately 70 miles. A 35 mile segment of the Baron Fork River and a 12 mile segment of Flint Creek are classified as scenic rivers upstream from their confluence with the Illinois River. The rest of the river basin in Oklahoma consists of Tenkiller Ferry Reservoir and a short segment downstream of the dam to its confluence with the Arkansas River.

The watershed lies with the Ozark Highlands and Arkansas Valley Ecoregions. The majority of the watershed in Oklahoma is in the Ozark Highland Ecoregion. This ecoregion is characterized by oak-hickory forests on well-drained soils of slopes, hills, and plains. Trees are of medium height (20 to 60 feet or 6 to 18 meters) with a relatively open canopy which allows a thick understory of slow-growing shrubs and trees. Areas of exposed rock are common. Blackjack oak, post oak, white oak, black hickory, and winged elm are the common overstory trees, and coralberry, huckleberry, and sassafras are representative of the understory. A taller forest community is found in protected ravines and on moist or north-facing slopes where soils are deeper and well drained. These forests are 60 to 90 feet (18 to 27 meters) high and consist of an overstory of sugar maples, white oaks, chinquapin oak, and hickory, with an understory of redbud, flowering dogwood, pawpaw, spice bush, sassafras and coral berry. Mosses, ferns, and liverworts are abundant on the moist forest floor. Bottomland hardwood forests of oak, sycamore, cottonwood, and elm exist along floodplains of larger streams. Elevations range from 1477 to 640 NGVD. Soils are derived mainly from chert and limestone.

The southern-most section of the watershed lies in the Arkansas Valley Ecoregion. This ecoregion forms the break between the Ozark Highlands and the Ouachita Mountains. Dry forests of short (50 feet or 15 meters tall) post oak, blackjack oak, and scattered hickories with significant cover of tallgrass prairie plants and little or no understory dominate rugged areas and extend into the plains. Shortleaf pine savannas occupy ridgetops of this ecoregion. Tallgrass prairie communities of bluestems, Indiangrass, switchgrass, and other tall grasses dominate the broad valley, interspersed with wildflowers, dry upland forests, and bottomland hardwood forests along streams. These tall (100 feet or 30 meters) bottomland forests consist of oak, elm, and hackberry and usually have two or three levels of trees below the overstory. Grape, poison ivy, and greenbriar vines are common in the understory. Elevations range from 1000 to 460 NGVD.

Major soils within the basin are in the Captina, Clarksville, Enders, Jay, Linker, Mountainberg, Nella, Nixa, Noark, Razort, Steprock, and Waben series (USDA 1992). The majority of the higher reaches of the watershed are Clarksville-Nixa-Noark; deep, loamy cherty soils

moderately to well drained, moderately to rapidly permeable. These soils are derived from cherty limestone. Soils in the vicinity of Lake Tenkiller are Enders-Linker-Mountainberg-Nella; deep, loamy, gravelly or stony soils derived from acid sandstone, siltstone, and shale. These well drained soils range from very slowly permeable to moderately rapidly permeable.
The population of the basin in Oklahoma is approximately 50,000 - 60,000 based on 1995 estimates (OWRB 1996). The number of people below the poverty level in the four Oklahoma counties is higher than the state average (**Table 1**). The education attainment of the four Oklahoma counties was below the state average except in Cherokee County where Northeastern Oklahoma University is located (**Table 2**).

The dominant industry in the basin is agriculture, primarily poultry and livestock. **Table 3** displays rankings of Oklahoma counties in agriculture. Livestock is not the only agricultural activity in the basin. Although only a small percentage of the watershed is cropped, intensive crops such as vegetables, strawberries, fruit orchards, and nurseries are an important part of the economy in Cherokee and Adair Counties.

Table 1. Population Percent Below Poverty Level (USDA 1992).

County/State	Persons	Families
Statewide-Oklahoma	13.4	10.3
Adair	27.6	22.1
Cherokee	22.2	18.3
Delaware	21.4	16.7
Sequoyah	20.1	16.3

Table 2. Education Statistics, 1980 (USDA 1992).

	Percent > 12 years	Percent > 16 years
Oklahoma-Statewide	66.0	15.1
Adair	45.1	8.7
Cherokee	56.2	17.8
Delaware	52.8	7.3
Sequoyah	48.2	8.3

Table 3. Oklahoma County Rankings in Agricultural Productivity (USDA 1992).

	County Ranking			
	Adair	Cherokee	Delaware	Sequoyah
Cash Receipts from Agricultural Products Sold	5	4		
Swine Production	2		1	
Number of Milk Cows in OK	2		4	

The watershed also has a significant recreation industry. Annual visitation to the river is about 400,000 with about 180,000 taking advantage of the floating opportunities (OSRC 1998). Lake Tenkiller also has one of the few and most noteworthy scuba diving opportunities in the state. Excellent fishing opportunities are also available on the Illinois River, Lake Tenkiller, Baron Fork Creek, and Flint Creek with over 68 game species available (OSRC 1998).

Land use in the Oklahoma portion of the watershed is illustrated in **Table 4** and **Figure 3**. Forest land (deciduous, evergreen, and mixed) makes up approximately 57 percent of the total watershed area. Agricultural land makes up approximately 38 percent of the total watershed area (A more specific view of some agricultural land is shown in a later section of this report. **Figure 12** displays locations of confined animal feeding operations in the watershed). Urban, transportation, and utilities areas make up approximately 3 percent of the watershed.

Table 4. Land Use of the Illinois River Basin in Oklahoma (1970-1980 USGS).

Land Use Category	Land Use Code	Area (m^2)	Area (mi^2)
Residential	11	46767802.33	18.06
Commercial and Services	12	8549757.01	3.30
Transportation, Commerce, Utilities	14	1015323.63	0.39
Other Urban or Built-up Land	17	5482459.55	2.12
Cropland & Pasture	21	813912103.00	314.25
Orchards, Nurseries, Ornamental Horticulture	22	5026276.57	1.94
Confined Feeding Operations	23	6594362.41	2.55
Other Ag. Land	24	1453287.53	0.56
Deciduous Forest	41	825790490.20	318.84
Evergreen Forest	42	4338258.94	1.68
Mixed Forest	43	413416922.80	159.62
Reservoirs	53	48709240.11	18.81
Nonforested Wetland	62	1872074.13	0.72
Beaches	72	149858.13	0.06
Strip mines, Quarries, Gravel Pits	75	86894.26	0.03
Transitional Areas	76	14801112.99	0.57

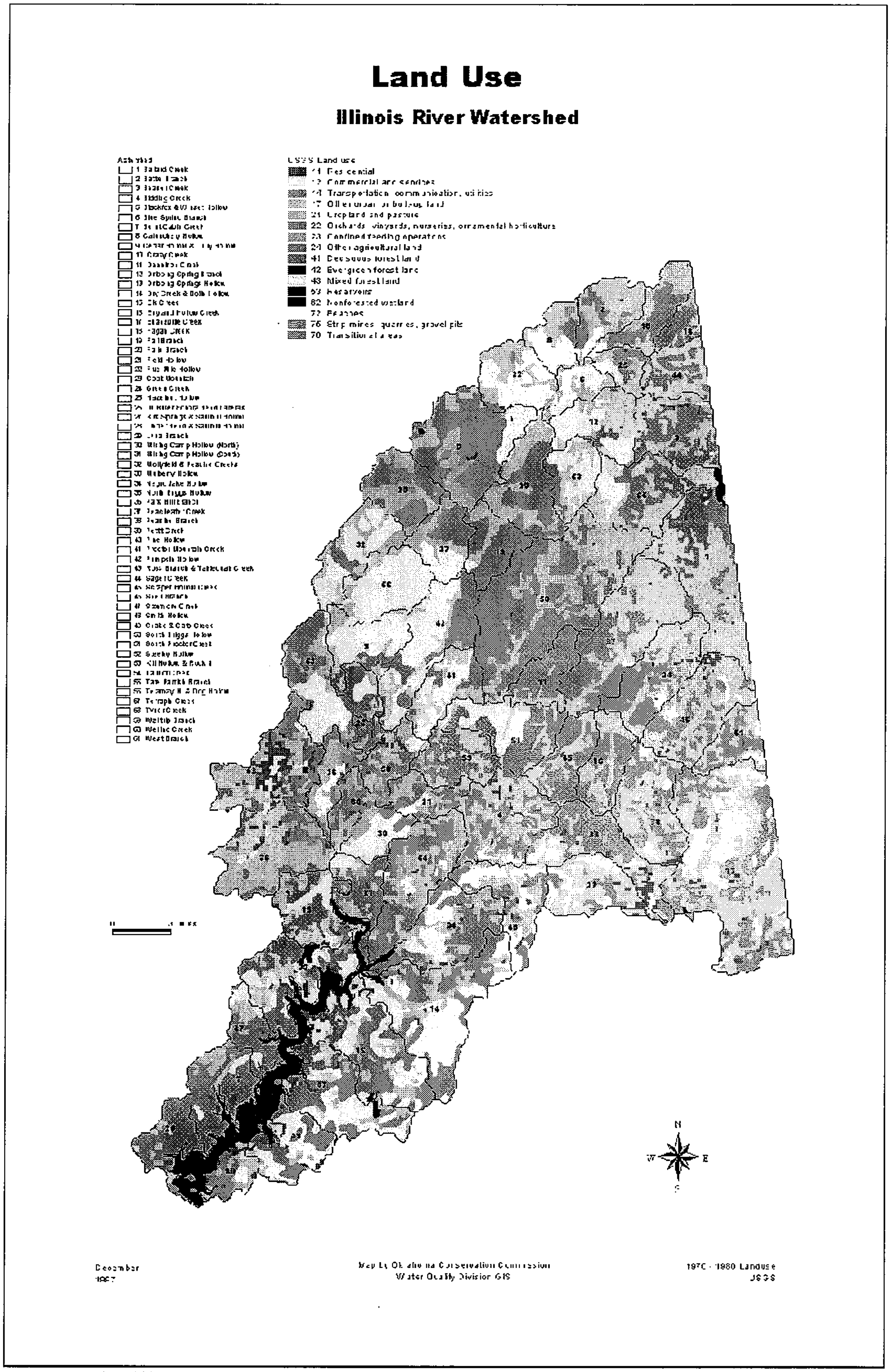

Figure 3. Land Use in Illinois River Basin in Oklahoma (1970-1980 USGS).

PROBLEMS AND CONCERNS

The Illinois River Basin has received as much attention as any other water resource in recent Oklahoma history. Most of this attention has focused on the perception that river quality has degraded over the past decade as a result of point and nonpoint source discharges.

Although some of the discussion of river degradation has been based upon public opinion, a considerable body of evidence indicates the river contains excessive levels of nutrients. In addition, studies in Lake Tenkiller indicate the upper portions of the lake have become eutrophic as evidenced by frequent and extensive algal blooms. Evidence to-date indicates that the source of the nutrients are both point and nonpoint source in nature with each contributing different proportions, dependent upon season and river flow volume.

Recent studies suggest a lesser known but perhaps even greater problem in the river and its tributaries is bank erosion. Bank erosion, primarily due to poor riparian management such as clearing native vegetation and overuse by livestock, is occurring at an alarming rate, contributing sediment and gravel to the streams and river. This causes shallowing and widening of the channels, resulting in loss of crucial habitat for benthic macroinvertebrate and fish populations. Although this degradation is most evident in the river and its tributaries, evidence will become increasingly apparent in the upper reaches of Lake Tenkiller as mud flats develop and turbidities increase.

Much of the understanding of problems in the basin has been generated through government projects and programs. While the data indicate that there are water quality problems, another important measure of the river's health is the public's opinion, especially in the eye of those who live in the river basin. Public opinion is particularly important when solutions for improving river quality are considered.

In order to develop an understanding of the public's opinion concerning the quality of water in the Illinois River, a series of public meetings were held in 1992. Each meeting focused on a different interest group in order to develop an understanding of that group's thoughts about the river. Each group was asked to identify and rank problems, identify and prioritize causes, and generate solutions for priority problems. The groups which met were decision makers (Indian tribes, municipalities, state government), nursery producers, recreational industry, and agricultural producers.

Taken together the groups agreed that the following pollution problems had occurred in the river:

Changes in fish populations
Wider and shallower river
Excessive growth of algae
Murky water

Stream bank erosion
Waste problems

The groups added that the following were problems and causes (listed in no particular order or relationship to one another):

Problems	Causes
recreation	nonpoint source pollution
poultry and agricultural waste	dumping of raw/treated sewage
open sewers	lack of education about wastes
loss of riparian areas	inadequate recreation facilities
sediment load from roads	development and growth
public apathy	waste dumping
confined animal operations	poor enforcement of trash laws
urban runoff	agricultural runoff
	solid waste
	tourism/recreation

Although some of these groups have specific interests in production activities within the basin, there was a noticeable lack of finger pointing. Each group recognized that the problems and causes were many and that contributions from all areas must be addressed. There was general agreement among the groups concerning pollution problems are their causes, although the prioritization of these factors varied.

Despite the extensive efforts to study and understand the condition of the river and the sources of pollution, no basin-wide plan to address pollution sources has been adopted. It has been recognized by all parties that any attempt to improve river quality must be based upon a comprehensive approach covering the entire basin. While this would seem to be an obvious approach to the problem, recent political history indicates that a diversity of opinion exists concerning pollution sources and their relative contribution to the problem.

WATER QUALITY STUDIES

Numerous projects have measured water quality of the Illinois River. These projects have not been coordinated to cover all areas of concern, nor have they been conducted in a consistent manner; however, despite these limitations, a substantial amount of information exists upon which to characterize river water quality. Many of these studies were reviewed and their findings condensed in a report titled "Evaluation and Assessment of Factors Affecting Water Quality of the Illinois River in Arkansas and Oklahoma" which was completed as a joint effort between Oklahoma State University and the University of Arkansas in 1991. Other important works which have been completed and are discussed in this document include a 1992 study which characterizes the natural, physical, and human resources of the basin (USDA et al.), a study of the quality of water from small streams which feed the river within Oklahoma (Oklahoma Conservation Commission, (OCC)), a report reviewing ten years of data collection on the river and major tributaries (Oklahoma Scenic Rivers Commission), and a Clean Lakes Phase I Diagnostic and Feasibility Study on Lake Tenkiller (Oklahoma Water Resources Board and Oklahoma State University). The following section will summarize the findings of these studies. The intent of this section is to familiarize the reader with some of the specific water quality issues which are important in the basin and is not intended to deal with all of the information which has been collected.

A. ARKANSAS/OKLAHOMA JOINT RIVER STUDY

The most thorough compilation of data from the Illinois River Basin is contained in the "Oklahoma State University (OSU) and University of Arkansas Cooperative Report on Evaluation and Assessment of Factors Affecting Water Quality of the Illinois River in Oklahoma and Arkansas".

The purpose of this report was to gather all information concerning water quality in the Illinois River Basin into a single document and to interpret the results. This is a lengthy document to which the reader is referred if additional or more detailed information is required. One of the major areas of focus was the identification of trends in the data over time and space which are discussed in the following sections.

1. Total Phosphorus

Spatial trends - statistically significant decrease in concentration from the Arkansas border to Tahlequah.

- statistically significant increase in concentration below Osage Creek.

Temporal trends - statistically significant increases at nine of seventeen sites.

Mean values were in excess of the recommended level of 0.05 mg/L at all sites with some being exceptionally high. The data summary for phosphorus is included in **Table 5**.

Table 5. Summary Statistics for Illinois River Sampling Stations for Total Phosphorus.

Station ID	Site #	n (months)	Total Phosphorus as P (mg/L)		
			Mean	Median	SD
USGS 07195000	1	134	1.082	0.755	0.927
SR 0.5	2	14	0.313	0.295	0.100
USGS 07195500	3	170	0.293	0.198	0.313
SR 1	4	64	0.265	0.233	0.151
SR 2	5	66	0.225	0.192	0.176
USGS 07195860	6	117	1.496	0.820	1.021
USGS 07196000	7	127	0.188	0.172	0.090
SR 3	8	66	0.211	0.184	0.098
SR 4	9	66	0.201	0.170	0.081
SR 4.5	10	14	0.200	0.187	0.090
SR 5	11	66	0.181	0.133	0.295
USGS 07196500	12	127	0.130	0.100	0.133
SR 6	13	62	0.845	0.387	0.936
SR 6.3	14	11	0.154	0.118	0.074
USGS 07197000	15	126	0.079	0.044	0.102

2. Nitrite/Nitrate

The data for summary is included in **Table 6**.

Spatial trends - statistically significant decrease in concentration from the Arkansas border to Tahlequah.

- increase in concentration below Osage Creek.

Temporal trends - statistically significant increases at most sites.

Mean values were high at all sites and exceeded recommended values of 1.0 mg/L.

Table 6. Summary Statistics for Illinois River Sampling Stations for Total Nitrogen.

Station ID	site #	n (months)	Total Nitrogen as N (mg/L)		
			Mean	Median	SD
USGS 07195000	1	108	4.081	4.000	1.262
SR 0.5	2	14	1.843	1.625	0.749
USGS 07195500	3	110	1.510	1.200	0.873
SR 1	4	64	1.819	1.800	0.966
SR 2	5	66	1.673	1.400	1.491
USGS 07195860	6	80	2.888	2.250	1.031
USGS 07196000	7	98	1.291	1.100	0.679
SR 3	8	66	1.480	1.475	0.778
SR 4	9	66	1.459	1.300	0.797
SR 4.5	10	14	1.357	0.417	0.647
SR 5	11	66	1.293	1.200	0.953
USGS 07196500	12	96	1.052	0.800	0.718
SR 6	13	62	2.245	1.600	1.619
SR 6.3	14	10	1.266	1.200	0.550
USGS 07197000	15	98	0.914	0.700	0.628

3. Nitrogen/Phosphorus Ratios

Nitrogen/phosphorus ratios are much lower from the river main stem and main tributaries than for the smaller tributaries. It can be seen by comparing the data from the two data sets that nitrogen values are relative similar, while phosphorus values are much higher at the main stem sites. This might indicate that point sources of phosphorus are playing a major role in maintaining high river values.

4. Nutrient Sources

Considerable attention was paid to the identification of nutrient sources, especially in regard to phosphorus loading. It was estimated that phosphorus loading from point versus nonpoint sources was approximately equal during low flow conditions but that nonpoint sources exceeded point sources during normal or high flows.

In terms of annual loading of phosphorus it was estimated that the loading at the upper end of Lake Tenkiller was 21% from point sources and 79% from nonpoint sources. Total point source loading of phosphorus was estimated to account for 12% of the Oklahoma total.

5. Effects on Lake Tenkiller

The primary conclusion that was drawn from the data was that phosphorus loading exceeds the levels, as predicted by Vollenweider's model, that would cause Lake Tenkiller to become eutrophic.

B. ILLINOIS RIVER COOPERATIVE RIVER BASIN RESOURCE BASE REPORT

The objectives of this report were to better define water quality problems of the Illinois River basin, to prioritize watersheds needing project action to improve water quality, and to develop separate water quality project plans on high priority watersheds in Arkansas and Oklahoma. This report covers a wide variety of subjects, including natural resources, human resources, problems, concern, ongoing activities, and recommendations. The main outputs of the report include three systems for designating priority watersheds developed by three different agencies; Arkansas Soil Conservation Service (SCS), Oklahoma SCS, and the Oklahoma Conservation Commission (OCC). These results are seen in **Table 7**, **Table 8**, and **Table 9**. The Arkansas SCS system was developed using potential nonpoint agriculture source data, land use, municipal water supply locations, benthic data, and chemical data. The Oklahoma SCS system was developed using potential nonpoint agriculture source data, land use, and watershed size. The OCC system was developed using potential agricultural nonpoint source data and water sampling data. The highest priority watersheds for both states are generally low order streams or headwater streams. Many of the highest priority subwatersheds in Oklahoma were tributaries of the Baron Fork Creek.

The report also included recommendations for improving environmental quality of the basin. Water quality plans were completed for Upper Osage, Little Osage, and Clear Creeks in Arkansas in 1992, and for Shell and Ballard Creeks in Oklahoma in 1991. These plans suggested voluntary adoption of conservation practices by producers with technical assistance provided by the SCS, cost share incentives provided by the ASCS, and a strong education and information program as the preferred methods to correct and prevent agricultural source nonpoint source pollution. Additional recommendations made in the report based on a review of studies summarized in the report included:

Table 7. Nonpoint Pollution Potential Rankings: Arkansas SCS Priority Watersheds

Rank	Watershed	County	Score	Map #
1	Clear Creek	Washington	3202	221
2	Upper Osage	Benton	3197	352
3	Little Osage	Benton	3186	375
4	Blair Creek	Washington	2684	420
5	Baron Fork of Ill. River	Washington	2400	820
6	Spring Creek	Benton	2281	380
7	Upper Moores Creek	Washington	2279	440
8	Ballard Creek	Washington	2163	081
9	Flint Creek	Benton	2134	610
10	Upper Illinois River	Washington	2094	140
11	Lower Osage Creek	Benton	2082	351
12	Ruby Creek	Washington	2037	120
13	Gum Springs Creek	Benton	NG	520
14	Fish Creek	Washington	NG	310
15	Little Flint Creek	Benton	NG	620
16	Wildcat Creek	Washington	NG	330
17	Galey Creek	Benton	NG	360
18	Hamstring Creek	Washington	NG	220
19	Wedington Creek	Washington	NG	720
20	Cincinnati Creek	Washington	NG	710
21	Lower Moores Creek	Washington	NG	430
22	Goose Creek	Washington	NG	130
23	Fly Creek	Washington	NG	840
24	Kinion Creek	Washington	NG	450
25	Brush Creek	Washington	NG	340
26	Muddy Fork of Ill. River	Washington	NG	410
27	Sager Creek	Benton	NG	630
28	Lick Branch	Benton	NG	371
29	Robinson Creek	Benton	NG	320
30	Gallatin Creek	Benton	NG	550
31	Evansville Creek	Washington	NG	830
32	Lake Wedington	Washington	NG	110
33	Puppy Creek	Benton	NG	392
34	Cross Creek	Benton	NG	391
35	Frances Creek	Benton	NG	510
36	Chambers Creek	Benton	NG	530
37	Pedro Creek	Benton	NG	540

NG: not given in report.

Table 8. Illinois River Cooperative River Basin Priority Watersheds, Oklahoma SCS.

Rank	Watershed	County	Rank	Watershed	County
1	Tyner Creek	Adair	31	Pumpkin Hollow	Adair
2	Peacheater Creek	Adair	32	Mulberry Hollow	Cherokee
3	Ballard Creek	Adair	33	Dry Creek and Bolin Hollow	Adair, Cherokee Sequoyah
4	Green Creek	Adair	34	Cedar Hollow & Tully Hollow	Cherokee
5	Tahlequah & Kill H., Rock Branch	Adair	35	Field Hollow	Cherokee, Adair
6	Battle Branch Creek	Delaware	36	Dripping Springs	Adair, Delaware
7	Shell Creek	Adair	37	Smith Hollow	Adair
8	Evansville Creek	Adair	38	Goat Mountain	Adair
9	Mollyfield, Peavine Hollow	Cherokee	39	Walltrip Branch	Adair, Cherokee
10	Scraper Hollow	Adair	40	Tailholt Creek	Adair, Cherokee
11	Peavine Branch	Adair	41	Mining Camp Hollow North	Cherokee
12	England Hollow	Adair	42	Linder Bend & Saw Mill Hollow	Sequoyah
13	Tate Parrish	Adair	43	Luna Branch	Adair
14	Bidding Creek	Adair	44	Pettit Branch	Cherokee, Sequoyah
15	South Briggs	Cherokee	45	Pine Hollow	Sequoyah
16	West Branch	Adair	46	Park Hill Branch	Cherokee
17	Sager Creek	Delaware	47	South Proctor Branch	Adair
18	Hazelnut Hollow	Delaware	48	Snake & Cato Creek	Sequoyah
19	Blackfox, Winset Hollow	Adair, Cherokee Delaware	49	Elk Creek	Cherokee, Sequoyah
20	Bluespring Branch	Cherokee	50	Terrapin Creek	Sequoyah
21	Fagan Creek	Delaware	51	Mining Camp Hollow South	Cherokee
22	Crazy Creek	Delaware	52	Burnt Cabin Creek	Sequoyah
23	Negro Jake Hollow	Adair, Cherokee	53	Sizemore Creek	Cherokee, Sequoyah
24	Fall Branch	Adair	54	Proctor Mountain Creek	Adair, Cherokee
25	North Briggs Hollow	Cherokee	55	Ross Branch & Tahlequah Cr.	Cherokee
26	Calunchety Hollow	Delaware	56	Kirk Springs & Sawmill Hollow	Adair, Cherokee
27	Falls Branch	Cherokee	57	Dripping Springs Hollow	Cherokee
28	Steeley Hollow	Cherokee	58	Dennison Creek	Adair
29	Beaver Creek	Adair, Delaware	59	Welling Creek	Cherokee
30	Five Mile Hollow	Delaware	60	Telemay & Dog Hollow	Cherokee

Table 9. Illinois River Cooperative River Basin Priority Watersheds - OCC.

Prioritization Based on Phosphorus			Prioritization Based on Nitrogen		
HU*	Name	Rank	HU*	Rank	Name
509	Tyner (L&U)		512	Peacheater	
330	Kill, Rock & Tahlequah		337	Ballard	
337	Ballard (L)		610	Fagan	
609	Sager	1	604	Battle Branch	1
518	Shell		518	Shell	
604	Battle Branch		514	England	
514	England		315	Mollyfield	
325	Fall Branch (East)		606	Hazelnut	
333	Tate Parrish		521	West	
610	Fagan		609	Sager	
521	West		515	Green	
504	Field	2	509	Tyner (L&U)	2
321	Fall Branch		333	Tate Parrish	
310	Cedar & Tully		330	Kill, Rock, & Tahlequah	
513	Scraper		607	Crazy	
323	Black Fox & Winset		603	Calunchety	
519	Peavine (E&W)		513	Scraper	
607	Crazy		519	Peavine (E & W)	
331	Dripping Springs Br.		404	Bidding	
315	Mollyfield	3	334	Beaver	3
309	Pumpkin		331	Dripping Springs Br.	
603	Calunchety		520	Evansville (L&U)	
512	Peacheater		325	Fall Branch (E)	
606	Hazelnut		602	Five Mile	
408	Goat		402	Negro Jake	
219	Bolin & Dry		408	Goat	
507	Walltrip Branch		227	Parkhill	
334	Beaver	4	409	Mulberry	4
520	Evansville (L&U)		323	Black Fox & Winset	
227	Parkhill		312	Steeley	
403	Tailholt		326	Luna	
404	Bidding		507	Walltrip Branch	

HU* Hydrologic Unit Number

Table 9. Continued.

Prioritization Based on Phosphorus			Prioritization Based on Nitrogen		
HU	Name	Rank	HU	Rank	Name
302	Ross & Town Branch		407	Smith	
515	Green		309	Pumpkin	
510	South Proctor (E&W)		510	South Proctor (E&W)	
204	Linder Bend	5	403	Tailholt	5
401	Negro Jake		321	Fall Branch	
213	Terrapin		310	Cedar & Tully	
225	Mining Camp South		502	Mining Camp North	
215	Sizemore		302	Ross & Town Branch	
218	Elk		216	Petit	
207	Burnt Cabin		212	Pine	
326	Luna		504	Field	
407	Smith	6	219	Bolin & Dry	6
312	Steeley		605	Bluespring Branch	
602	Five Mile		506	South Briggs Hollow	
216	Petit		509	Proctor Mountain	
212	Pine		307	North Briggs Hollow	
409	Mulberry		225	Mining Camp South	
502	Mining Camp North		215	Sizemore	
506	South Briggs Hollow		209	Cato & Snake	
605	Bluespring Branch	7	204	Linder Bend	7
309	Kirk Spr./Sawmill		511	Dennison	
209	Cato & Snake		319	Kirk Spr./Sawmill	
307	North Briggs Hollow		218	Elk	
314	Dog & Telemay		213	Terrapin	
	Missing Data			**Missing Data**	
226	Dripping Spr. Hollow		207	Burnt Cabin	
508	Proctor Mountain		314	Dog & Telemay	
511	Dennison		226	Dripping Spr. Hollow	
503	Welling Creek		503	Welling Creek	

1. Continued support of governor's animal waste task force in Arkansas as means to coordinate agency programs and projects and identify inadequacies, overlap, and/or conflict in animal waste regulations or guidelines.
2. A complete review of existing regulation, legislation, and agency policies concerning animal waste in Oklahoma to determine deficiencies.

3. Comprehensive study of groundwater quality coordinated with nonpoint source programs where possible and continued support of ongoing groundwater monitoring.
4. Continue to streamline and develop new practices to protect water quality.
5. Further develop and support technology to compost and market poultry litter as a soil improvement.
6. Continue to develop water quality farm plans, particularly in priority watersheds in response to local concerns and needs.
7. Develop an intensive educational program to educate the public, landowners, and operators about the extent of the nonpoint source pollution problem, the potential to their operation to contribute to the problem, and sources of available assistance.
8. Basin residents and government agencies need to be innovative in developing and implementing measures to protect, improve, or enhance water quality in the basin by:
   - evaluating existing programs, laws, and policies to determine potential contributions to water quality improvement and necessary modifications and expansions.
   - identification of need and development of new programs
   - establishing an effective monitoring program
   - Establishment of a governor's advisory group in Oklahoma to support water quality issues and provide a forum for economic growth while minimizing impacts on the environment.
9. Phosphorus discharge limits based on the cumulative phosphorus capacities in Lake Tenkiller and the Illinois River should be included in all point source discharge permits.

C. OKLAHOMA SCENIC RIVERS COMMISSION - RIVER TREND STUDY

The data from samples collected by the Oklahoma Scenic Rivers Commission was analyzed to determine existing and historic water quality conditions, as well as any trends which might be present. An excellent historic data base exists for several sites where monthly samples have been collected since December 1980. This report covers the analysis of approximately 120 samples collected between 12/80 and 10/92 from each of the following sites:

Camp Paddle Trails
Fiddlers Bend
Chewey Bridge
Round Hollow
Echota Bend
Illinois River below the Tahlequah Creek confluence
Flint Creek
Sager Creek

Other sites have been sampled less frequently due to changes in sample site location and other factors; therefore, less data exists from these sites, and that which exists may be temporally disrupted or may cover a limited duration. Despite these limitations, some of this data is very useful in interpreting stream conditions. This includes the following sites:

Peavine Hollow
No Head Hollow
Baron Fork
Hwy 59 bridge (Arkansas)
Hwy 16 bridge (Arkansas)
Illinois River above Osage Creek (Arkansas)
Illinois River above Flint Creek

1. Trend Analysis

Method I

Trend analysis is used to determine long-term changes in water quality. There are several methods available for accomplishing this; however, in this report the Seasonal Kendall Tau test was performed utilizing the WQSTAT software package developed by Woodward-Clyde and Colorado State University.

Taken as a whole, the data from the long-term sites show few trends and those trends which exist are of a low magnitude. This indicates that there has been little change in the quality of water at theses sites over the almost twelve year sampling period. It should be mentioned that there is a high degree of variance in the data, that is, values fluctuate widely from month to month. Some of this fluctuation is due to changes in river volume; therefore, if values could be looked at in terms of loading, the data would probably be more uniform. The wide degree of data variance probably masks some trends. Trends which were found to be statistically significant (95% confidence level) are listed in **Table 10**.

The best overall conclusion that can be drawn from this data is that chemical oxygen demand (COD) appears to be dropping at several sites, but that turbidity seems to be increasing. Given the amount of variance in the data, these analyses are largely un-satisfactory; therefore, long-term changes will be looked at in another fashion.

Table 10. Temporal trends found in Scenic Rivers Commission Study (1980-1992).

Site	Trend	Parameter
Camp Paddle Trails	positive	turbidity
Fiddlers Bend	negative	COD
Fiddlers Bend	negative	phosphorus
Chewey Bridge	negative	COD
Chewey Bridge	positive	phosphorus
Chewey Bridge	positive	turbidity
Round Hollow	negative	COD
Echota Bend	negative	COD
Echota Bend	positive	turbidity
IR blw. Tahlequah Cr.	negative	COD
IR blw. Tahlequah Cr.	positive	turbidity

Method II

Another way that the time sequence data can be looked at is to compare average values during early years to that of later years. In this case data averages for the first two years have been compared to those of the last two years of sample collection as listed in **Table 11**.

Table 11. Water Quality in the Illinois River Basin (1980/81 vs. 1991/92).

Site	Date	COD	TN	TP	TSS	TURB.
Paddle Trails	80/81	10.6	2.02	0.253	17.6	11.1
	91/92	6.6	2.49	0.236	20.1	12.3
Fiddlers Bend	80/81	7.1	1.78	0.223	9.5	4.1
	91/92	3.7	2.22	0.170	6.4	3.9
Chewey Bridge	80/81	6.3	1.62	0.195	7.2	4.4
	91/92	4.5	1.98	0.170	4.3	5.0
Round Hollow	80/81	6.6	1.71	0.196	6.3	3.2
	91/92	4.0	2.02	0.166	5.2	3.1
Echota Bend	80/81	6.8	1.40	0.090	5.4	2.8
	91/92	4.1	1.93	0.115	5.9	2.8
IR blw. Tahlequah	80/81	8.7	2.45	0.475	11.9	4.7
	91/92	7.6	4.37	0.825	4.5	2.5
Baron Fork	80/81	4.6	1.59	0.152	2.2	1.2
	91/92	4.4	1.85	0.315	2.7	1.5
Flint Creek	80/81	4.5	1.54	0.041	3.1	2.7
	91/92	3.7	2.14	0.111	4.5	1.5
Sager Creek	80/81	6.9	3.13	1.008	2.4	1.1
	91/92	11.3	5.76	0.724	1.8	1.9

COD = Chemical Oxygen Demand (mg/L); TN = Total Nitrogen (mg/L); TP = Total Phosphorus (mg/L); TSS = Total Suspended Solids (mg/L); Turb. = Turbidity (NTU).

On the whole, averages from the two time periods are not very different, which corroborates that there has not been much of a trend over the years of the study. Again it should be mentioned that there was considerable variation within the two-year periods; therefore, mean values may be weighted by unusual events and differences in means may not be statistically significant.

Total nitrogen increased at all sites between the two periods. Although these increases were not generally of a large magnitude, the fact that they occurred at all sites leads to the conclusion that nitrogen loading has increased in the Illinois River (**Figure 4**).